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CRITICAL EVALUATION OF INSULATED
SHALLOW BURIED PIPE SYSTEMS N.W.T. CANADA

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1. INTRODUCTION

Over the past four to five years in the Northwest Territories, Canada, a basic system and concept design has evolved for piped water and sewer systems suited to northern conditions throughout the continuous and discontinuous perma frost zone.

The history of piped systems in perma frost regions has been for the most part a sad and expensive one. When the average engineer south of 60 thinks of piped systems in northern Canada he envisages the much publicized "Inuvik type" of above ground utilidor. To my way of thinking the "Inuvik type utilidor" is a thing of the past and should not be duplicated again in new northern systems given present technologies.

The system that has replaced the "Utilidor" consists of individually insulated shallow buried water and sewer mains as opposed to the multiple pipes in a box above ground.

In November 1978 the Engineering Division of the Department of Public Works, Government of the Northwest Territories sponsored a Design Seminar in Yellowknife, in an effort to standardize and improve the buried insulated pipe systems being installed in the various N.W.T. communities.

The seminar brought together involved consultants, contractors, Regional operation and maintenance personnel, material suppliers and Project Engineers to review past problem areas and proposed improvements prior to proceeding with design work for 1979. The review and recommendations concerning buried insulated pipe systems presented in this paper are largely drawn from the discussions which took place at the seminar as well as tests and trials on new methods that took place shortly after the seminar.

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Shallow buried pipe systems have or are being installed in Norman Wells, Resolute, Frobisher, Rankin Inlet and Ft. Rae. This covers the full range of northern conditions from ice rich soils to gravels; from discontinuous to continuous perma frost; from areas of dramatic temperature variation below the tree line to high Arctic conditions.

1.1 System Description

The shallow buried system can best be described under the following headings:

- mode of operation
- system objectives
- components

1.1.1 Mode of operation

For the water system the mode of operation is a single pipe recirculation system. This consists of one or more uninterrupted loops eminating from a recirculating facility and returning to that facility without any branch systems. The water is pretempered in the recirculation facility prior to distribution. Positive system monitoring is maintained through simple flow and temperature alarms on the return line. Standby pumps and back up emergency power is provided.

The sewer system is operated as a normal gravity system.

1.1.2 System objectives

The shallow buried piped system is designed to meet the following objectives:

- minimize energy input to operate
- be simple to operate and maintain
- be protected against mechanical damage, vandalism and severe climate conditions.
- should be designed to allow maximum use of short construction season.

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1.1.2 cont'd

- have a prime anti-freeze mechanism with at least one back up mechanism if not two
- should be capable of being drained
- should have a minimum 20 year design life.
- should be capable of easily isolating sections and service lines at any time of the year.
- should be designed to and/or prefabricated to minimize on site labour
- should meet all of the above objectives and remain economically practical.

1.1.3 Components

The main system components are as follows:

1.1.3.1 Water and sewer transmission mains These consist of individually insulated shallow buried water and sewer lines placed in the same trench. Pipe material is high density polyethylene. Insulation is high density urethane applied to the pipe in a factory process. The exterior surface of the insulation is covered by an extruded impermeable plastic jacket. In addition the mains will have a minimum of one if not more back up freeze protection systems. These consist of such systems as heat trace, thaw tubes, thaw wires and bleeding. The mains both water and sewer are pressure rated and continually joined through the butt fusion process.

1.1.3.2 Service manholes (mini service centre) are placed at a maximum spacing of 100 m. Service manholes are designed and constructed so as to allow all servicing to be done from the manholes out of the weather in a heated dry environment. All water valves, sewer clean outs, heat trace, power terminations, hydrants, hydrant draining and valving and thaw tube terminations are done inside a suitably sized buried concrete structure.

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1.1.3.3 Service connections are done via a service bundle consisting of a 100 mm sewer line, two - 25 mm water lines and a heat trace line in one insulated pipe package. Main stops and curb stops are combined and placed as close as possible to the main. Valve boxes from main stops are brought to the surface of the ground to allow for valve operations to isolate service lines.

1.1.4 Conclusion

It is noted that the system differs greatly from standard southern distribution systems and so it should. Northern conditions require new solutions and new standards and should not be hampered in any way by system standards developed for more temperature climates.

1.2 Evolutionary History of Shallow Burdied Systems in the N.W.T.

In order to have some appreciation as to the rationale leading up to the present shallow buried system design and thus a better understanding for the subsequent critical recommendations to change and improve the system, it is important to first, very quickly, go through its evolution in the N.W.T.

Prior to 1972 in perma frost regions the utilidor piped system either corrugated metal or wood box was prevalent. The majority were above ground and presented serious problems both in the initial installation and subsequent on going maintenance and operation. Heaving piles were prevalent on above ground systems of this type. When they were placed at ground level or just below leakage and water infiltration destroying the insulation was a common occurence. If they were to be successful high energy input in one form or another was a must.

The typical utilidor had no manholes as such but separate boxed apertures for valves, hydrants, cleanouts, etc., were provided. The necessity of working on these critical areas exposed to the elements during the middle of winter always was a forbidding thought and when it did happen in most instances the utilidor never seemed to quite get put

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back together the way it was when it was first built.

A classic example is the 1972 Norman Wells utilidor which by 1979 after continual pile heaving and a number of freeze ups should be taken out and replaced. The only thing keeping it going is the continuously large amount of steam heat tracing.

A corrugated underground utilidor in Rankin Inlet was constructed in 1974. Manholes were used on this system consisting of vertical round corrugated sections with 50 mm of polyurethane foam applied to the inside. Sewer and water lines ran through the manholes with closed cleanouts on the sewer. Because of the airspace between the pipes and the insulated outer corrugated box and due to unlimited infiltration the entire system became a large running storm sewer. If you stopped the water from running it would freeze around the pipes but keeping it going has gradually meant deterioration of the insulation. The manholes being only 1 m in diameter by 1 m deep were too small to effectively work in under northern conditions and clothing.

Hydrants on this system were brought out in a separate box with a siamese connection to the outside. Unfortunately the long stem off the mains gave continual freezing problems.

After the corrugated metal attempt in Rankin the first shallow buried individually insulated pipe system was installed there in 1975. Again with corrugated metal type manholes and again with water infiltration and space problems. The hydrants were put outside on line with two isolating valves.

Because the hydrant couldn't drain it had to be filled with Propylene Glycol so it wouldn't freeze in case the valve leaked. The inherent problem with this type of hydrant was the fact that you have two valves and valve boxes which were problems to get at and maintain in operable condition. Also you had to depend on the local volunteer fire fighters to refill them with Propylene Glycol after use.

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The mode of operation tended toward single pipe recirculation but had many branches causing freeze ups to occur.

The next advancement was the use of precast concrete manholes in the first phase of the Frobisher Bay services extension in 1976. All other components such as hydrants were similar to Rankin Inlet 1975. The concrete manhole in Frobisher had benched open sewers with the water lines running through partially grouted. The manholes greatly improved the size with respect to working space. Any infiltration which was a problem was removed through the open sewer. This manhole also contained an electric heater and all electric terminations and panels for main line heat trace systems. With the continuous damp atmosphere in the manhole all electrical fittings even though explosion proof became quickly corroded.

In 1977 in Resolute Bay square concrete manholes were again used but this time with hydrants in the manholes self draining as per a normal hydrant to a sump in the manhole where the water is pumped through a back flow preventor to a closed sewer line in the manhole. The sewer line had a closed cleanout. All heat trace terminations and an electric heater were placed in the manhole. This alleviated the problems with hydrants but infiltration problems through heat trace conduits and pipe manhole interfaces were still prevalent to the point where the sump pump couldn't keep up during spring runoff.

All the above described installations starting with the initial Rankin Inlet shallow buried individually insulated pipe system in 1975 utilized electric heat trace for a prime anti freeze back up protection for both water and sewer lines. High density polyethylene pipe was used on all early systems with the exception of Norman Wells where Schedule 80 welded steel pipe was used and the first two phases of Frobisher Bay where ductile iron pipe was used.

The capital and operating costs associated with the electrical heat trace systems were extremely high. Initial capital cost with all things considered is approximately $60 per metre. If thermostats became unreliable caused by high moisture conditions or faulty placement of

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sensors as was often the case electrical operating costs at 10 to 15¢/kwh skyrocketed. Also many burn outs and faulty circuits were found after one year of operation.

The lack of reliability and high capital and O & M costs for electric heat tracing brought the use of such a back up system into serious question. Our experience from 1975 to 1978 has shown that given a positive circulating loop system with back up power and standby pumps, NOT ONCE has there been a main water or sewer line freeze up necessitating the use of a back up thaw system such as electric heat trace.

There was and is however a very real requirement for some form of back up thaw system in the event of a totally frozen pipe. The design must allow for the ability to easily thaw out the pipe with minimum cost or damage to the system. While polyethylene has the distinct advantage of being able to withstand freeze thaw cycles without affecting its performance, being plastic it is limited in the number of methods that can be used to thaw out such a pipe. Extreme heat such as steaming and electric resistance welding cannot be used. Electric heat trace is one method that can be used but at a high cost. The question is how much insurance do you need.

Accordingly, by 1977 electric heat tracing was placed only in water lines and not sewer lines. Sewage temperatures through monitoring of early years were found to average + 10°C and above in the insulated pipe package. A potential freeze time in a no flow blockage condition was greater than 24 hours. Thus the alarm caused by a sewage backup would be known well before any freezing takes place. During the past two years where no heat trace on sewer lines have been provided there have been no problems with freeze ups whatsoever on main lines.

In 1978 thaw tubes were introduced as part of the main water lines in Frobisher Bay and Fort Rae and eliminated electric heat trace totally on main lines.

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Thaw tubes used in lieu of electric heat trace consist of 25 mm HDPE tubing placed on top of the main carrier water line pipe and run from manhole to manhole. Heat transfer cement is used at the interface between the thaw tube and the main pipe to provide a larger heat transfer surface. The tubes are left empty and capped inside the manholes ready for use. Each manhole is provided with a 19 mm water valve at the main water line and a hose hung inside the vault complete with suitable fittings to connect from the main to the thaw tube or from thaw tube to thaw tube or to an electric booster heater prior to connection to thaw tube depending on the requirement.

It was our opinion prior to construction in 1978 that the thaw tube system would give more flexibility while providing the necessary back up insurance against freezing with a minimum of capital and on going operating cost. Thus it was tried in two out of four major installations in 1978.

Possible modes of use are as follows:

1.2.1 To bypass main line when it is being worked on for whatever reason and yet maintain service and circulation. This would simply be a connection from the main to the thaw tube and back to the main at the next appropriate manhole. Isolation valves on the main line are placed in every second manhole.

1.2.2 * To Thaw Out a Main Line Freeze up.

In this condition two pieces of equipment provided with the system are utilized.

The first, an electric heating unit of 3 000 kw capacity and weighing approximately 16 lbs is hung inside the manhole. The hose connection placed on a main in a manhole where water isn't frozen is connected to the heater and from the heater to the thaw tube. A flow controller limiting flow to 2 L per minute is used on the outlet side of the heating unit, The heating unit is connected to an electric out-

* - diagram

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let which is installed in every manhole for this and other maintenance purposes. The water coming out of the thaw tube at the next manhole is bled via the sump pump to the sewer line. Theoretical calculations show that a totally frozen 150 mm water main 100 m long at -5°C could be thawed completely to 1°C in approximately 26 hours. To do this same job using a nominal 4 watt per foot heat trace in the thaw tube would take approximately ten days.

1.2.3 To utilize heat trace in the thaw tube

This would be used where a dead section (non recirculating) is put into service off a main loop but will form part of the loop at a later date. Heat trace thermostatically controlled could be used in the thaw tube to be later removed once the line forms part of a larger circulating loop.

1.2.4 To be used as a return line

To be used as a return line in conjunction with a circulating pump on lines similar to those described in 1.2.3 above. In this instance instead of heat trace, circulation provides freeze protection by returning water from the dead end line via the thaw tube and a circulating pump to the main circulating loop. This again would only be done on a temporary basis or for very small branches that cannot be serviced otherwise.

1.2.5 Utilize the thaw tube as carrier pipe

Utilize the thaw tube as carrier pipe for externally provided hot water. In this case in lieu of using the electric heater provided,a larger oil fired hot water generator can be used to thaw lines very quickly over long lengths.

Our experience using the above thaw tube system mainly in Frobisher to date has again showed up the questionable need for a back up thaw system such as heat trace. Since we have experienced no problems with the main system having gone through one winter (including one of the worst two week blizzards in living memory) we have not had an occasion to use the thaw tube and thus judge their effectiveness from an operational experience. Hopefully we never will! However, tests will be carried out

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shortly on sections of the Fort Rae system allowing certain sections that aren't in use to freeze and then be thawed out.

1.3 System Evaluation

With the above background in mind I would like now to look at the system components in detail under the following headings; current problems and alternate solutions; and final recommendations to be used as N.W.T. standards for the shallow buried insulated system.

1.3.1 Water & sewer transmission mains

1.3.1.1 Back up thaw systems main lines

1.3.1.2 Existing There are two current thaw systems in use on Polyethylene pipe. These are electric heat trace and the thaw tube.

Electric heat trace
Advantages - continual temperature monitoring
Disadvantages - high initial capital cost $60/m
- high operating cost
- questionable reliability

Thaw tube
Advantages - low initial capital cost $6/m
- flexible use
- low operating cost - in Frobisher runs between manholes on heat trace, in November cost approx. $500 per power unit. The same length of line with thaw tubes in the same period cost $45.
Disadvantages - manual as opposed to automatic start up.

1.3.1.3 Other possible solutions looked at in this area are:
- placement of heat trace inside the pipeline. This has been successfully tried on a force main in Baker Lake. While extremely cost effective

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for long transmission mains such as Baker Lake, on normal service mains it would have the same disadvantages as normal heat trace plus added fittings on pipes. However, it does have the distinct advantage of being the most efficient way of transferring heat. In conjunction with Chemelex, tests are being carried out to see what effects freezing and thawing will have on the heat trace inside the pipe.

- placement of a thaw tube inside Tests using series 160 25 mm pipe inside a pipe were conducted in conjunction with DuPont of Canada Ltd. The results showed that the interior thaw tube unless filled with a non freezing fluid (which would complicate matters) completely collapses when the main line filled with water is frozen.

1.3.1.4 Recommendation Exterior HDPE thaw tubes will be used on all systems constructed in the in the N.W.T. in 1979. Thaw tubes should be the minimum series possible to suit the given conditions in order to maximize the heat transfer capability. Thaw tubes will be utilized on water lines only. Sewer lines will have no back up thaw mechanism.

1.3.1.5 Water infiltration main lines Existing circumstances with heat traced lines still show an infiltration problem which is directly related to design and/or installation. Lines installed with thaw tubes have shown little or no infiltration entering the manholes.

1.3.1.6 Recommendation Since thaw tubes will be utilized in future, infiltration should be minimized. Given present standards for joint sealing using mastic and heat shrink sleeve over preformed half shells; it is considered any deterioration of insulation will be minimal and acceptable over the 20 year life of the system. Field inspection however, should pay special attention to ensuring proper heat shrink sleeve and heat shrink tape techniques are adhered to. It is considered one of the major causes of infiltration lies in this area where the pipe exterior has not been properly cleaned and dried prior to applying heat shrink sleeves or tape.

Insulation Thickness - based on thermal analysis and temperature monitoring the economic optimum thickness that will be used as standard is 50 mm on shallow buried systems.

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1.3.2 Service Manholes (Mini Service Centre)

1.3.2.1 Existing problem areas and proposed solutions

1.3.2.2 Manhole size Initially it was attempted to standardize on one size for a given contract to allow for precasting and shipping to the site. However, many manholes were too small to adequately house all fittings, hydrant, valves, etc. Many contractors preferred to cast in place and thus precasting in the south didn't become a factor. But, on larger jobs precasting in situ at a central batch plant has distinct advantages. With larger concrete manholes the size of the sections cast are limited by equipment available to move them.

Because of the above many suggestions were made to use steel in lieu of concrete. While the advantages of steel with respect to prefabrication and shipping are of value it is considered such disadvantages as corrosion maintenance, temperature warping at opening, possible floating and grounding problems outweighed the advantages.

1.3.2.3 Recommendation Manholes will be made of concrete in standard sizes as noted below. Minimum size to suit appropriate situation. All manhole sizes, if precast, can be cast in 600 mm sections and moved using normal equipment.

Standard sizes

a) 1400 x 1400 mm
b) 1400 x 1700 mm
c) 1400 x 2000 mm
d) 1400 x 2300 mm
e) 1700 x 1700 mm
f) 1700 x 1700 mm
g) 1700 x 2300 mm
h) 2000 x 2000 mm
i) 2000 x 2300 mm
j) 2300 x 2300 mm

1.3.2.4 Water infiltration into manholes As discussed previously this problem has mainly occurred with heat trace conduits entering the vault. Many commercially available products appear to be on the market that have proven to be successful in this area and are being investigated and specified

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As an alternate to the pipe running through the concrete wall an alternate solution is to cast in place a flanged spool piece complete with water stop in the middle of the concrete wall. This gives positive infiltration protection and allows the PE pipe to be flange connected on the outside of the manhole. The draw back with this is that the thaw tube connection either must have a specifically fabricated pipe connector in the flanged spool piece or a separate spool piece of its own. A separate spool piece of its own means it would necessitate bringing it out of its insulated jacket prior to connection at the manhole and complicate insulating at this point.

1.3.2.5 Recommendation Pipes entering the manhole will have insulation removed to 15 cm outside the manhole wall and enter the manhole wall bare. The bare pipes will be wrapped with an approved mastic sealer prior to grouting in place.

1.3.2.6 Sump pump controls Sump pump controls used to date have not provided adequate level control as they would only come on after about 30 cm of water lay in the bottom of the manhole above the sump hole. Controls had to be bypassed and placed on manual to remove the water.

Recommendation - more appropriate commercially available sump controls have been found which will come on and off within the elevation limits of the sump hole (30 cm) and will be specified on all future work.

1.3.2.7 Cleanout location Existing cleanouts consisting of a rigid steel cover bolted to the top of a special in line fitting are made so as to be able to rod both ways up the line. Some concern at the seminar was expressed as to ensure they are placed away from the manhole opening. While this would work well in one direction it certainly would be a problem in the other direction especially if the snake or power auger is being fed from the top of the manhole.

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1.3.2.8 Recommendation Cleanouts will be placed so as to allow best possible access with a power auger through the manhole opening. This usually means access must be vertically close to the opening.

1.3.2.9 Exterior manhole insulation protective cover Manholes are insulated on the exterior with 100 mm of styrofoam made for exterior use. This works well where it is buried next to the manhole. But on the top of the manhole even if a 15 cm earth cover is placed over it, this usually becomes exposed and damaged. To prevent this in Resolute Bay and Rankin the insulation was placed under a concrete top on top on a metal plate which acts as a mechanical protection barrier within the manhole. It was considered that while being superior to earth being placed on top of the insulation as practised in Frobisher it was too extravagant and wasteful in concrete.

1.3.2.10 Recommendation Exterior top manhole insulation will be protected in one of two standardized methods depending on grade situations as detailed below.

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1.3.2.11 Manhole cover size and insulation Manhole covers used have been 600 mm and 750 mm standard cast iron covers and frames. An interior prefabricated insulated cover has been used on the inside as a frost cover. Because of frosting and fitting problems with the interior covers these have tended to be discarded shortly after installation. An attempt was made to obtain cast iron covers with sufficient depth built into its casting to foam this area in and have only a one cover system. In some instances it worked such as Frobisher and Ft. Rae while in Resolute it didn't since foaming in situ was not carried out well. This method however, prevents freezing problems as enough heat is allowed to escape around the frame to prevent covers frosting shut.

1.3.2.12 Recommendation Manhole covers will be standardized using 750 mm opening to allow easy entry with northern clothing. Cover to have sufficient depth in its casting to allow a minimum of 50 mm of foam in this cavity protected by plywood underneath.

1.3.2.13 Main line isolating valves Concern has been expressed as to the reliability of standard wafer butterfly valves being used at present. Corrosion on handles in some instances had prevented proper operation. Small obstacles in pipeline pebbles etc., also prevent proper closing. The number and placement of isolating valves was also questioned.

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1.3.2.14 Recommendation Gate valves shall be used in lieu of butterfly valves. Gate valves shall be of a flanged connection type with buna N seal so as to seal around small pebbles, etc. Valves shall be placed at a minimum spacing of every second manhole to ensure adequate system operational flexibility.

1.3.2.15 Manhole heaters Manhole electric heaters used to date are 500 watts wall mounted for dry environment (except those used in first phase of Frobisher) and controlled by a built in thermostat with rough settings of low, medium and high. It has been found that with a setting of medium the vaults have been too warm approximately 20°C. A proper thermostat away from the heater would cost as much as the heater itself.

1.3.2.16 Recommendation It is recommended to continue to use the same heaters but settings should be set as low as possible or manually turned off and only used if required.

1.3.3 Service Connections

1.3.3.1 Service bundle connection problems Severe connection problems have been experienced using the service bundle (consisting of 100 mm HDPE sewer, a heat trace cable and two - 25 mm HDPE water lines in one pipe bundle) both at the main line connection and at the entry to the housing unit.

Attempts have been made to come up with standard preformed insulating components at the mains to be used where the water lines separate from the sewer out of the bundle. These attempts have not worked and to this date the best approach here using the bundle is to foam in place a box around all the appurtanences as is shown on the attached sketch. This method is expensive (because of small field foam packs used) and time consuming. If done in cold weather (below freezing) does not produce an adequate job. If the line has to be dug up at this point then the foam box must be ripped out and entirely replaced.

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Connections at the houses especially to existing houses often require the sewer to be run to one location and the water lines to another. With the service bundle this means either the water lines or sewer line must be separated at some point and either run under or through the house. This requires field insulation of pipes and has often been the source of service line freeze ups.

Because of the above the entire service bundle philiosophy has been reviewed. Other systems looked at are; a preinsulated pipe pack for two water lines and heat trace including flexible insulation and jacket; a preinsulated 75 mm conduit containing two water lines and a heat trace in a bundle; and a separate 100 mm insulated sewer line without heat trace.

One of the advantages of the bundle is that the sewer line does not require a separate heat trace. When separated, the sewer line without heat trace runs the possible risk of freeze up without any easy thaw method.

1.3.3.2 Recommendation Service connections will be made using a dual pipe system in the same trench. Water lines and heat trace will be either "pipe pack" package or strung through a 75 mm preinsulated conduit as described above. Sewer line will be a separate 100 mm preinsulated HDPE pipe without heat trace. The above systems can be connected easily to the mains using existing prefabricated insulation and coverings. The sewer and water lines can enter the house separately where desired.

1.3.3.3 Main stops/valve boxes Previous systems have utilized valve boxes and actuators off the main stops to isolate service lines. Experience has shown that these are expensive to install and have been a constant source of problems. Since most northern systems are installed in gravel roads, snow removal equipment, no matter how well the boxes are marked, regularly jar the boxes resulting in disconnection of the main stops and leaks. The rationale as to their need and benefit is seriously questioned. With a continuous non joined run of HDPE water pipe from main to house the only possible leaks can either be at the main or at the house but not in between. If its at the main digging is required anyway. If its at the house, valves are placed at the entry point.

1.3.3.4 Recommendation Valve boxes will not be installed on all future installations.

1.3.3.5 Service boxes under houses With the service bundle the entry to the house was terminated in an insulated box constructed under the house as per the attached sketch. The box because of foundation shifting often allowed air infiltration and has been the cause of service line freeze ups.

1.3.3.6 Recommendation Service boxes under houses are to be eliminated. Dual pipe system to be used. Insulated pipe to be taken directly through the floor and connected in open heated air space.

1.3.3.7 Service line heat trace back ups Because of problems with thermostat sensor placements and freeze ups from various causes described above, the heat trace is often kept on by the home resident as well as the circulating pump. This has resulted in a needless waste of energy.

1.3.3.8 Recommendation Heat trace to be activated by flow switch under no flow condition. This eliminates thermostats and possible waste of energy.

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1.4 Cost Evaluation

Earlier a list of objectives were set out for the design of an insulated shallow buried pipe system. It is considered that the majority of the objectives have been met and demonstrated in our system that we have just reviewed. The exception, however, is the last one and that is:

" The system should meet all of the objectives and remain economically practical."

To demonstrate that our system meets this last objective I would like to review the cost evolution of the Frobisher Bay System. Recently tendered costs for 1979 are based on a design incorporating all of the above recommendations.

For the standard 150 mm water line and 200 mm sewer line complete with hydrant/manholes, electrical, etc., in the same trench the cost for both individually insulated pipes per metre is as follows:

Phase I	1976	$880/lin. m
Phase II	1977	$424/lin. m
Phase III	1978	$390/lin. m
Phase IV	1979	$315/lin. m

Despite inflation, with more experience, standardization, and new technologies costs as demonstrated have continued to decrease. In fact costs now in Frobisher are comparable to Yellowknife, and a far cry from the expensive Inuvik Model T in which present versions comparable to the above cost approximately $475/m.

1.5 Summary

This paper summarizes the work of the past few years in the Northwest Territories in which it has been attempted to achieve a good standardized, economically practical, Northern Pipe System. The system described here, I beleieve is second to none and is the result of a

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cooperative effort between Government, the construction industry, maintainence personnel, material suppliers and consultants towards achieving the objectives set out. This cooperative effort was aptly demonstrated when all of the above players including c0-competitors took part in the Shallow Buried Pipe System Design Seminar in Yellowknife last fall.

It is hoped to hold and expand such design seminars on an annual basis not only to continue to improve the shallow buried pipe system but to review similar standards in other areas which are at an equal stage in development. Such areas are river, lake and reservoir intakes; truck fill pumphouses. packaged truck and honey bag sewage disposal stations, water storage tanks and long transmission mains.

Gentlemen, I believe a new level of maturity and growth has been reached in the north; one which has gone a long way towards normalizing man's habitation of such a harsh environment.

Date Due

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